

# Ichthyofauna from three streams of the lower Iguatemi River in the upper Paraná river basin, Brazil

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## Abstract

The ichthyofauna from 3 streams (Água Boa, Perobão, and Santa Maria) to the lower Iguatemi River were inventoried, which is located in the upper Paraná river basin, in Mato Grosso do Sul state, Brazil. Sites in the upper, intermediate, and lower portions of each stream were quarterly electrofished from March to December 2008. All sampled fish ( $n = 6,816$  individuals) represented 43 species of 5 orders, and 16 families. The most abundant species was *Phalloceros harpagos* (63.5%), followed by *Astyanax* aff. *paranae* (10.6%), *Hypostomus ancistroides* (5.9%), *Gymnotus inaequilabiatus* (3.4%), and *Knodus moenkhausii* (2.7%). Despite the high ichthyofauna richness in the lower portion of Iguatemi River, the need to implement and/or expand soil conservation practices and riparian forest restoration is of utmost importance to maintain these populations in the long term.

## Keywords

Diversity; floodplain; freshwater fishes; preservation; re-establish.

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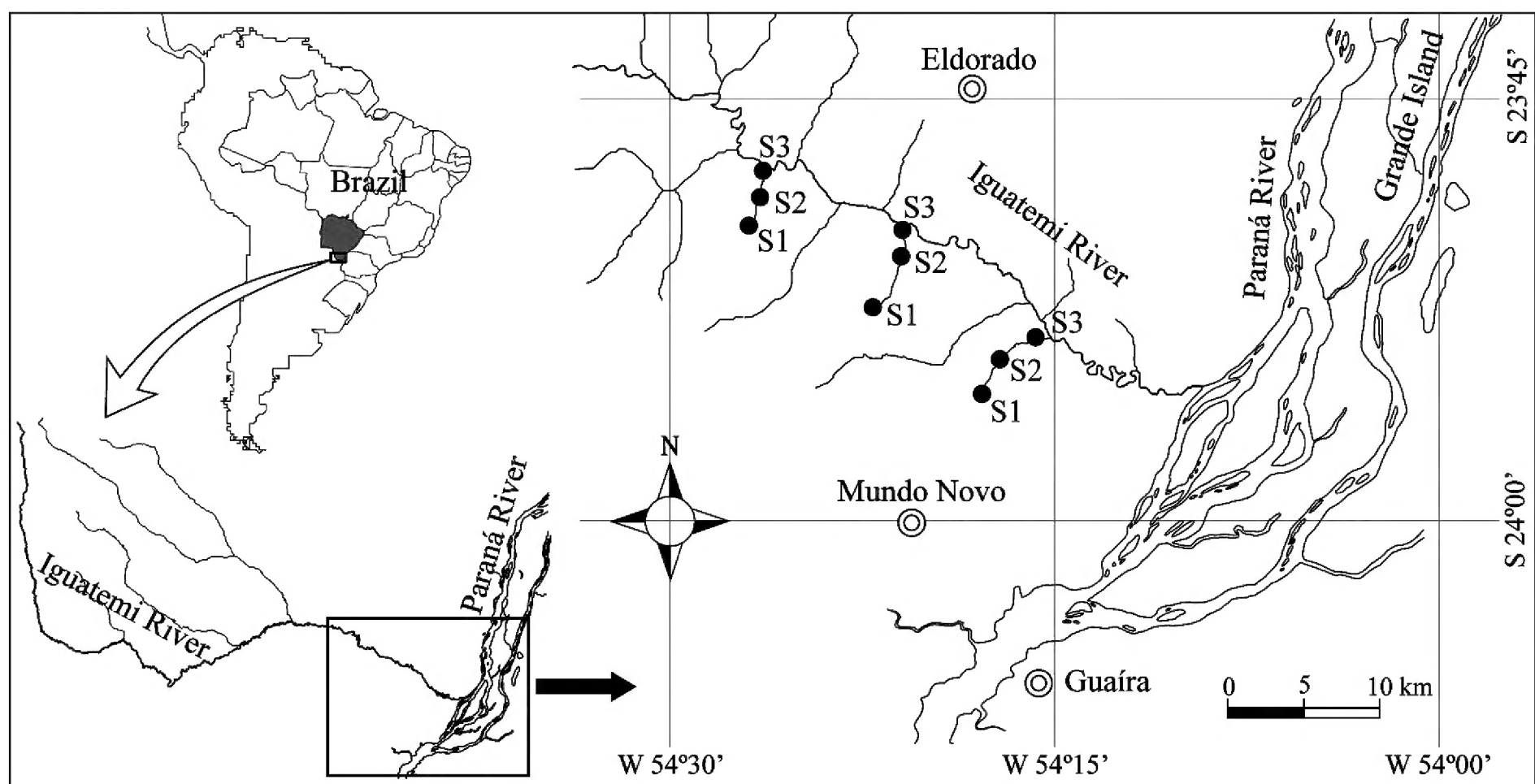
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## Introduction

The South American freshwater fish fauna is the most diverse on earth (Albert et al. 2011), with about 20 orders, 69 families, 739 genera, and 5,160 valid species (Reis et al. 2016). Of these, approximately 310 species, including both native and non-native species, are found in the upper Paraná river basin (Langeani et al. 2007). Small tributar-

ies and streams of this basin harbor a great concentration of small-bodied species of fish (Castro 1999, Winemiller et al. 2008), with little or no commercial value, which correspond to around 50% of the richness of freshwater fish species in tropical regions (Lowe-McConnell 1999, Winemiller et al. 2008).

Despite the representativeness of Brazilian streams fish fauna in Neotropical biodiversity and its contribu-



**Figure 1.** Location of Perobão, Água Boa and Santa Maria streams and sampled sites at each stream. S1 = site 1, upper portion; S2 = site 2, intermediate portion; S3 = site 3, lower portion.

tion to the functioning of ecosystems, the composition of fish species in Brazilian streams is still poorly reported in the literature (Castro et al. 2003, Langeani et al. 2007, Winemiller et al. 2008). Although relatively well known compared to elsewhere in South America, the ichthyofauna of the upper Paraná river basin also requires further investigations (Langeani et al. 2007). Such a lack of information on the species composition of fish assemblages is particularly pronounced at the lower portion of the Iguatemi River, a right bank tributary of the upper Paraná river basin (see Suárez and Petrere-Júnior 2003, 2005, 2006).

The Iguatemi River, mainly in its lower section, is located within the limits of the area of influence of flood pulses of the upper Paraná River floodplain. This area corresponds to an extensive floodplain, mainly in the Mato Grosso do Sul state, and represents a very dynamic ecosystem in biotic and abiotic terms (Agostinho et al. 2009), presenting a high environmental heterogeneity and importance for biodiversity maintenance (Thomaz et al. 2007). Since the knowledge on fish species living in a river basin is essential for any measure of management of fishery resources and/or water quality and habitats (Oliveira et al. 2014), we present a list of fish species for 3 first-order streams, tributaries to the Iguatemi River, within the limits of the upper Paraná River floodplain.

## Methods

**Study area.** Água Boa, Perobão, and Santa Maria are first-order streams, which run for about 6.0, 4.3, and 5.3 km, respectively, in rural areas in southern Mato Grosso do Sul, Brazil. Only the headwater of the Santa Maria stream is located in the urban area of the municipality of Mundo Novo. All the 3 streams flow into the right bank

of the Iguatemi River, upper Paraná river basin (Fig. 1). These streams are surrounded by poor arboreal riparian forest. The native vegetation is the Atlantic Forest biome (semi-deciduous forest), which has been largely replaced with agriculture and pasture. Deforestation is a remarkable characteristic of the history of regional occupation (Suárez and Petrere-Júnior 2003). Siltation is another anthropogenic stressor. The soil in the region is sandy and frequently impacted by gullies, intensifying the input of sediments into the streams; added to this, rural populations indiscriminately use the water from streams for livestock, which worsens the siltation process due to animal trampling (Mendonça et al. 2014). Garbage accumulation is another impact on the Santa Maria stream given its contact to urban areas.

**Data collection.** Samplings were conducted quarterly from March to November, 2008 (Brazilian license 146/2007, IBAMA/SISBIO) in the upper (Site 1), intermediate (Site 2) and lower (Site 3) portions of Água Boa, Perobão, and Santa Maria streams. Each sampling site shows distinct characteristics of width, depth, flow, streambed, and riparian vegetation (for more details, see Table 1). Fish were caught using electrofishing (portable generator TOYAMA 1600, 220V, DC). The sampling effort was standardized for each stream and the different months. Each sampled portion length was determined according to Fitzpatrick et al. (1998), wherein we took 5 width measurements in each portion (emphasizing the environmental heterogeneity including the regions of run, riffle, and pool). Later, we calculated the arithmetic mean of these measures and multiplied the result by 20. The length of the upper, intermediate, and lower portion sampled were 82 m, 71 m, and 50 m for the Água Boa stream, 94 m, 57 m, and 61 m for the Perobão stream, and

**Table 1.** Environmental features and sampled area at Água Boa, Perobão and Santa Maria streams. Site 1 = upper portion; Site 2 = intermediate portion; Site 3 = lower portion. Minimums and maximums are shown for width and depth.

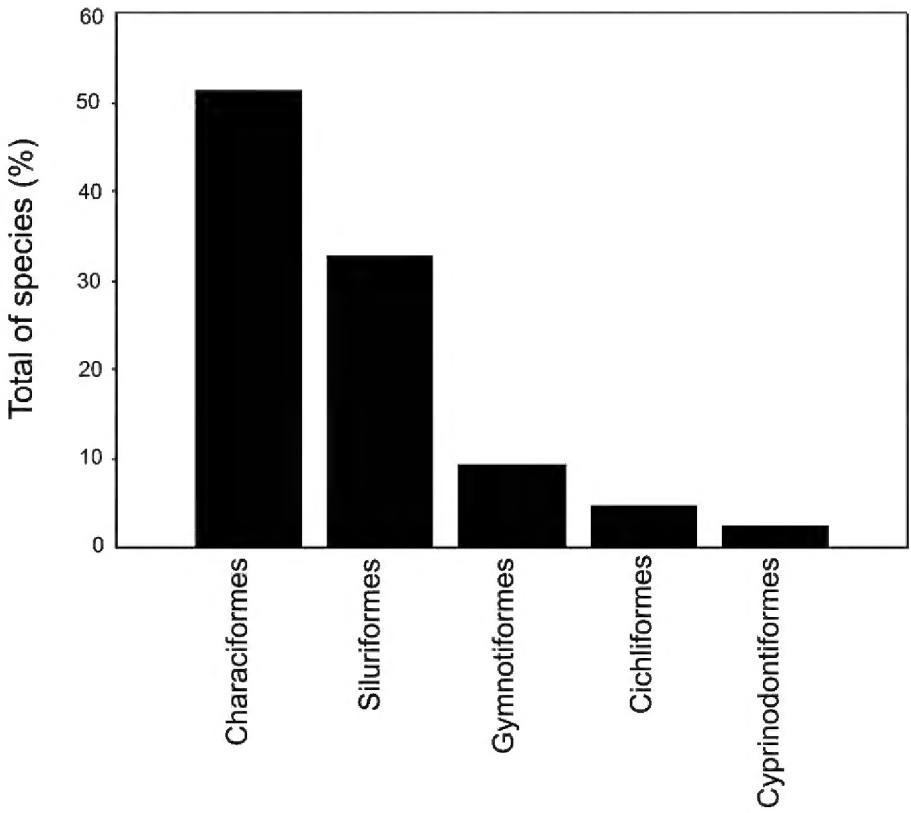
Stream	Site	Latitude (S)	Longitude (W)	Width (m)	Depth (cm)	Flow conditions	Stream bed	Riparian vegetation	Principal impacts
Água Boa	1	23°52'42.24"	054°21'55.37"	2.0–6.0	12–15	Backwaters	Clayey; abundant aquatic grasses	Marginal veg.: scattered trees, shrubs & grasses	Deforestation; grazing
	2	23°50'16.65"	054°20'55.54"	2.2–5.5	30–90	Backwaters alternating with rapids & pools	Rocky & sandy	Marginal veg.: small clusters of trees & pasture grasses	Recreational activities
	3	23°50'03.33"S	054°20'58.53"	2.2–2.7	30–63	Rapid water flow	Sandy	Marginal veg.: scattered trees, shrubs & grasses	Grazing; fish farming (natural course altered)
Perobão	1	23°49'25.26"S	054°26'43.30"	2.0–10.0	5–15	Backwaters	Clayey, slightly steep banks	Marginal veg.: mainly pasture grasses	Intense transit of cattle
	2	23°48'59.35"S	054°26'40.06"	1.0–4.5	10–50	Pools & rapids, rapids prevailing	Predominantly rocky & sandy; steep banks	Narrow band of riparian veg. & pasture grasses	Deforestation; grazing
	3	23°48'05.50"S	054°26'26.00"	2.0–3.6	26–45	Alternating backwaters, rapids & pools	Rocky & sandy; slightly sinuous, with steep bank & limited downstream by a waterfall (about 3 m)	Scarce marginal veg.: scattered trees & pasture grasses	Deforestation; grazing
Santa Maria	1	23°55'22.75"S	054°17'49.54"	0.7–1.2	12–19	Straight channel that receives culvert flow	Clayey; steep banks	Marginal veg.: scattered trees, shrubs & grasses	Deforestation; grazing
	2	23°54'29.17"S	054°17'14.49"	0.9–3.0	20–50	Rapid water flow	Clayey bed; somewhat steep banks	Marginal veg.: grasses & some shrubs	Deforestation; grazing
	3	23°53'52.44"S	054°16'13.55"	1.6–4.6	15–80	Straight channel next to fish farming; low flow	Rocky & sandy	Marginal veg.: grasses	Deforestation; grazing

19 m, 37 m and 63 m for the Santa Maria stream. Blocking nets were installed at the end of each portion (10 m × 2 m and mesh size of 0.5 cm between opposite nodes) to prevent fish from escaping. A single electrofishing pass was used to collect the fish in each portion.

The specimens were euthanized in benzocaine and fixed in 10% formalin. In the laboratory, specimens were sorted and placed in glass vials containing 70% alcohol. Identification followed Graça and Pavanelli (2007) and/or via specialist verification. Taxonomic classification followed Reis et al. (2003), Betancur et al. (2017), and Ferraris (2007) particularly for Siluriformes. Voucher specimens were deposited in the fish collection of the Nupélia (NUP: Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura), Universidade Estadual de Maringá, Maringá, Paraná (NUP 16119 to NUP 16122, NUP 16138 to NUP 16148, NUP 16151 to 16185, and NUP 16170). The species were categorized by their constancy of occurrence, which was calculated for each stream according to Dajoz (1983). Species with a frequency of occurrence up to 25% were classified as occasional, between 25 and 50% as an accessory, and above 50% as constant. In addition, the species were categorized into autochthonous and allochthonous, respectively, to distinguish native and introduced species to the upper Paraná river basin (Graça and Pavanelli 2007, Langeani et al. 2007, Júlio Júnior et al. 2009).

Results

The number of fish caught (*n* = 6,816 individuals) represented 43 species, in 5 orders, and 16 families (Table 2). Characiformes (Fig. 2) was the most representative order in number of species and families (22 species and 7 families), followed by Siluriformes (14 species and 4 families), Gymnotiformes (4 species and 3 families), Cichliformes (2 species and 1 family) and Cyprinodontiformes (1 species). Characidae (12 species), Loricariidae (6 species)



**Figure 2.** Percentages of the total number of sampled species in each order.



**Table 2.** List of fish species of Água Boa, Perobão and Santa Maria streams. N = total number of individuals collected, CO = constant, AC = accessory, OC = occasional, Auto = autochthonous, Allo = allochthonous, AB = Água Boa, PE = Perobão, SM = Santa Maria.

Species	Constancy				Origin	Voucher
	N	AB	PE	SM		
Characiformes						
Anostomidae						
<i>Leporinus friderici</i> (Bloch, 1794)	02	—	—	OC	Auto	NUP16161
Characidae						
<i>Aphyocharax anisitsi</i> Eigenmann & Kennedy, 1903	03	OC	—	—	Auto	NUP16143
<i>Aphyocharax dentatus</i> Eigenmann & Kennedy, 1903	02	OC	—	—	Auto	NUP16145
<i>Astyanax</i> aff. <i>fasciatus</i> (Cuvier, 1819)	01	—	—	OC	Auto	NUP16174
<i>Astyanax</i> aff. <i>paranae</i> Eigenmann, 1914	722	AC	CO	OC	Auto	NUP16121
<i>Astyanax lacustris</i> (Lütken, 1875)	135	CO	—	AC	Auto	NUP16175
<i>Piabarchus stramineus</i> (Eigenmann, 1908)	108	AC	—	CO	Auto	NUP16148
<i>Knodus moenkhausii</i> (Eigenmann & Kennedy, 1903)	187	AC	—	CO	Allo	NUP16172
<i>Moenkhausia australe</i> (Eigenmann, 1908)	31	AC	—	OC	Auto	NUP16167
<i>Moenkhausia bonita</i> Benine, Castro & Sabino, 2004	17	AC	—	AC	Auto	NUP16181
<i>Oligosarcus pinto</i> i Campos, 1945	03	—	—	OC	Auto	NUP16165
<i>Piabina argentea</i> Reinhardt, 1867	15	—	—	OC	Auto	NUP6171
<i>Serrapinnus notomelas</i> (Eigenmann, 1915)	107	AC	—	AC	Auto	NUP16177
Crenuchidae						
<i>Characidium gomesi</i> Travassos, 1956	01	—	—	OC	Auto	NUP16179
<i>Characidium</i> aff. <i>zebra</i> Eigenmann, 1909	14	AC	OC	OC	Auto	NUP16144
Curimatidae						
<i>Cyphocharax modestus</i> (Fernández-Yépez, 1948)	02	OC	—	—	Auto	NUP16142
<i>Steindachnerina brevipinna</i> (Eigenmann & Eigenmann, 1889)	04	OC	—	OC	Allo	NUP16155
Erythrinidae						
<i>Hoplerythrinus unitaeniatus</i> (Agassiz, 1829)	01	—	—	OC	Allo	NUP16156
<i>Hoplias</i> sp. 3	12	OC	AC	OC	Auto	NUP16160
Lebiasinidae						
<i>Pyrrhulina australis</i> Eigenmann & Kennedy, 1903	44	AC	—	—	Auto	NUP16147
Parodontidae						
<i>Apareiodon affinis</i> (Steindachner, 1879)	03	—	—	OC	Auto	NUP16183
<i>Parodon nasus</i> Kner, 1859	02	—	—	OC	Auto	NUP16169
Cyprinodontiformes						
Poeciliidae						
<i>Phalloceros harpagos</i> Lucinda, 2008	4329	AC	CO	AC	Auto	NUP16120
Gymnotiformes						
Gymnotidae						
<i>Gymnotus inaequilabiatus</i> (Valenciennes, 1839)	232	CO	—	AC	Allo	NUP16157
<i>Gymnotus pantanal</i> Fernandes, Albert, Daniel-Silva, Lopes, Crampton & Almeida-Toledo, 2005	07	—	—	AC	Auto	NUP16162
Hypopomidae						
<i>Brachyhypopomus</i> aff. <i>gauderio</i> Giora & Malabarba, 2009	01	—	—	OC	Allo	NUP16163
Sternopygidae						
<i>Eigenmannia guairaca</i> Peixoto, Dutra & Wosiacki, 2015	03	AC	—	—	Auto	NUP16151
Cichliformes						
Cichlidae						
<i>Cichlasoma paranaense</i> Kullander, 1983	50	OC	CO	—	Auto	NUP16222
<i>Crenicichla britskii</i> Kullander, 1982	23	CO	—	CO	Auto	NUP16221
Siluriformes						
Auchenipteridae						
<i>Trachelyopterus galeatus</i> (Linnaeus, 1766)	06	OC	—	—	Auto	NUP1885
Callichthyidae						
<i>Callichthys callichthys</i> (Linnaeus, 1758)	16	AC	—	OC	Auto	NUP16223
<i>Corydoras aeneus</i> (Gill, 1858)	71	AC	OC	CO	Auto	NUP16185
<i>Hoplosternum littorale</i> (Hancock, 1828)	04	—	—	OC	Auto	NUP16158
Heptapteridae						
<i>Imparfinis schubarti</i> (Gomes, 1956)	104	OC	AC	CO	Auto	NUP16168
<i>Pimelodella avanhandavae</i> Eigenmann, 1917	04	OC	—	—	Auto	NUP16139
<i>Pimelodella gracilis</i> (Valenciennes, 1835)	02	OC	—	—	Auto	NUP1874
<i>Rhamdia quelen</i> (Quoy & Gaimard, 1824)	36	AC	AC	CO	Auto	NUP16159
Loricariidae						
<i>Farlowella hahni</i> Meinken, 1937	15	AC	—	—	Auto	NUP16140

Table 2. Continued.

Species	Constancy				Origin	Voucher
	N	AB	PE	SM		
<i>Hypostomus iheringii</i> (Regan, 1908)	47	AC	—	—	Auto	NUP16153
<i>Hypostomus ancistroides</i> (Ihering, 1911)	400	AC	CO	CO	Auto	NUP16184
<i>Hypostomus strigaticeps</i> (Regan, 1908)	34	AC	—	—	Auto	NUP16138
<i>Otothyropsis polyodon</i> Calegari, Lehmann & Reis, 2013	15	AC	—	OC	Auto	NUP16171
<i>Rineloricaria</i> sp.	01	—	—	OC	Auto	NUP16170

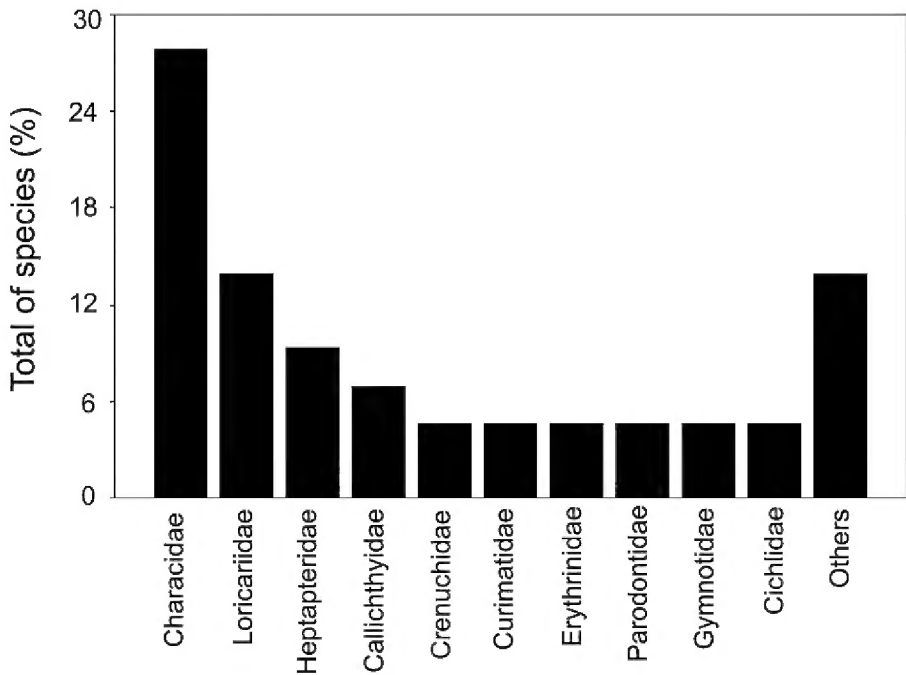


Figure 3. Percentages of the total number of sampled species in each family.

and Heptapteridae (4 species) presented higher richness, contributing together with 51.2% of all species (Fig. 3). *Phalloceros harpagos* Lucinda, 2008 (4,329 individuals), *Astyanax* aff. *paranae* Eigenmann, 1914 (722 individuals), *Hypostomus ancistroides* (Ihering, 1911) (400 individuals), *Gymnotus inaequilabiatus* (Valenciennes, 1839) (232 individuals), and *Knodus moenkhausii* (Eigenmann & Kennedy, 1903) (187 individuals) were the most abundant species, contributing with 86.1% of the collected individuals (Fig. 4). On the other hand, 19 species represented fewer than 10 individuals.

Regarding species richness, we identified 31 species (11 exclusive) at Água Boa stream, 31 (12 exclusive) at Santa Maria stream, and nine at Perobão stream (Table

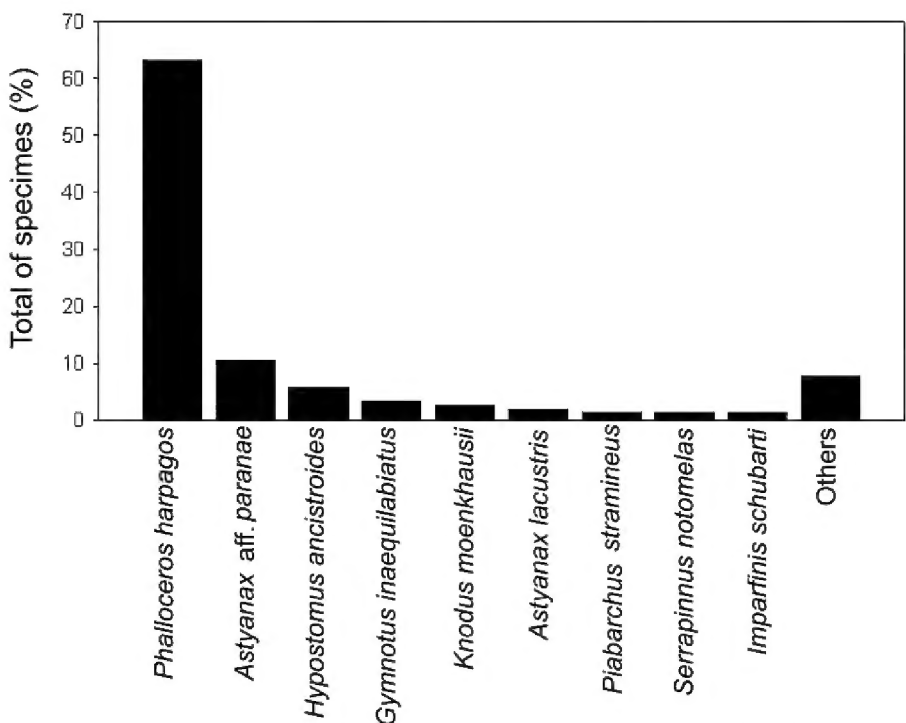


Figure 4. Percentages of number of specimens of each species with more than 100 individuals captured.

2). As for constancy of occurrence, most species recorded at Água Boa stream were characterized as accessory (18 species among 31 captured), at Perobão stream as constant and accessory (4 among 9 captured), while at Santa Maria stream, fish fauna was mainly made up of occasional species (18 among 31 captured) (Table 2). In considering the origin of species, there was a predominance of autochthonous species (88.3%); only 5 were classified as allochthonous: *Brachyhypopomus* aff. *gauderio* Giora & Malabarba, 2009, *G. inaequilabiatus*, *Hoplerythrinus unitaeniatus* (Agassiz, 1829), *K. moenkhausii*, and *Steindachnerina brevipinna* (Eigenmann & Eigenmann, 1889). Short descriptions following Graça and Pavanelli (2007) and/or taxonomic revisions for all captured species are herein provided, as well as photographs of some captured species (Fig. 5).

Order Characiformes

Family Anostomidae

*Leporinus friderici* (Bloch, 1794)

*Salmus friderici* Bloch 1794: 94 [original description].

*Leporinus friderici*—Graça and Pavanelli 2007: 38, 41.

**Material examined.** Table 2; Figure 5A.

Elongated body; terminal mouth; premaxilla and dentary with 4 teeth, no maxillary teeth. Lateral line with 37–41 pored scales; transversal series above lateral line with 4–5½ scale rows and below with 4–5½ scale rows. Dorsal fin with 11 or 12, pectoral fin with 15–17, pelvic fin with 9, anal fin with 10 and caudal fin with 19, total rays (Garavello 1979). Ground color silvery to yellowish; dorsal portion of iris red; 3 dark-brown rounded or oval, horizontally elongated, blotches on flank; region of contact between flank scales below lateral line with orange or red spots, forming longitudinal series. Fins yellowish.

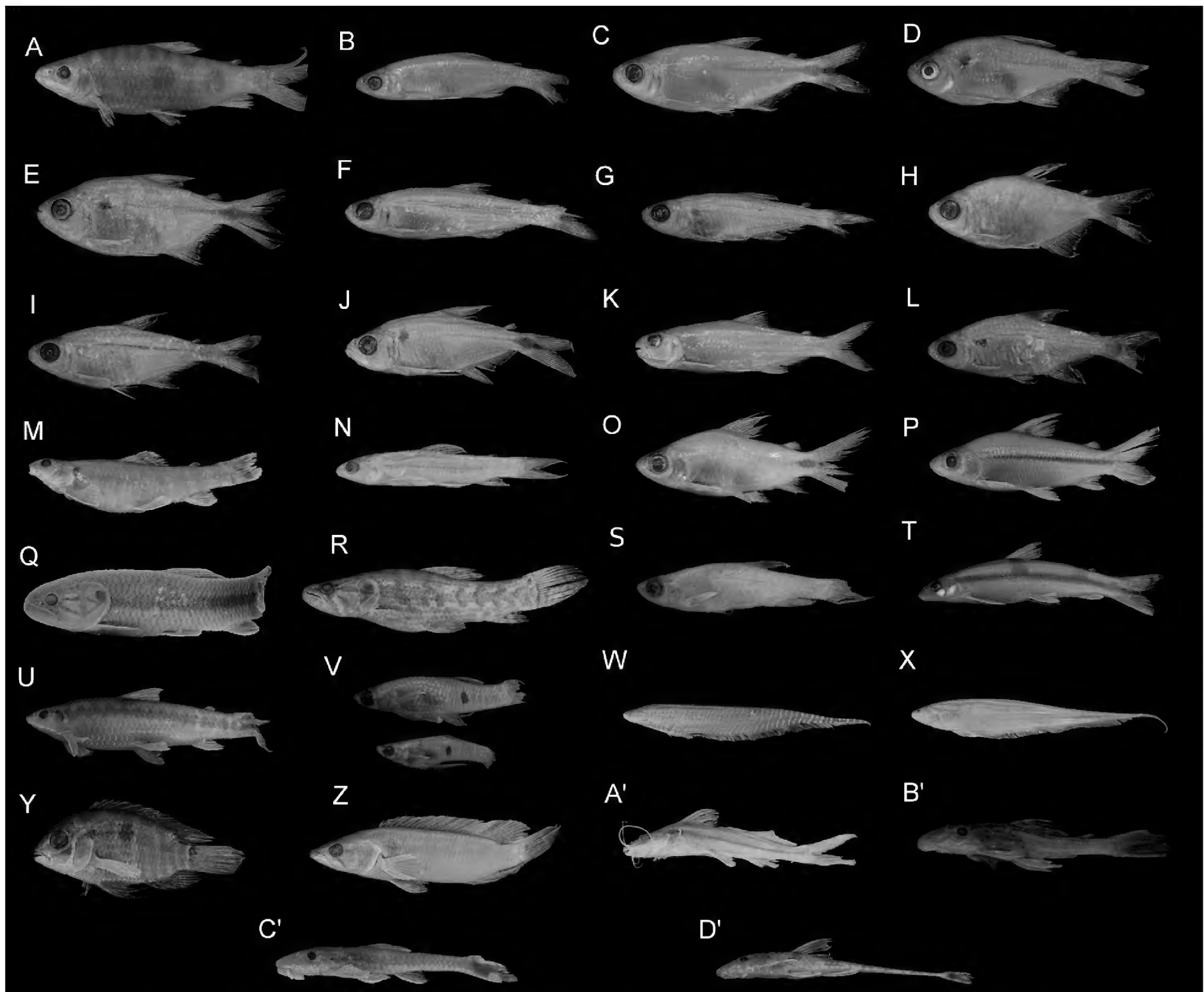
Family Characidae

*Aphyocharax anisitsi* Eigenmann & Kennedy, 1903

*Aphyocharax anisitsi* Eigenmann and Kennedy 1903: 517 [original description]—Graça and Pavanelli 2007: 86, 87.

**Material examined.** Table 2.

Elongated body; terminal mouth; premaxilla with 4–8 teeth, dentary with 7–14, and maxilla with 1–4 teeth. Lateral line incomplete, with 7–10 pored scales; longitudinal series with 30–34 scales; transversal series above lateral line with 4–5 scale rows and below with 3½–5 scale rows. Dorsal fin with 9–11, pectoral fin with 9–12,



**Figure 5.** Some fish species from streams of the lower Iguatemi River in the upper Paraná river basin. **A.** *Leporinus friderici*, NUP 16161, 102.0 mm SL. **B.** *Aphyocharax dentatus*, NUP 16145, 36.8 mm SL. **C.** *Astyanax* aff. *fasciatus*, NUP 16174, 73.1 mm SL. **D.** *Astyanax* aff. *paranae*, NUP 16121, 40.3 mm SL. **E.** *Astyanax lacustris*, NUP 16175, 40.1 mm SL. **F.** *Piabarchus stramineus*, NUP 16148, 41.1 mm SL. **G.** *Knodus moenkhausii*, NUP 16172, 24.6 mm SL. **H.** *Moenkhausia australe*, NUP 16167, 28.1 mm SL. **I.** *Moenkhausia bonita*, NUP 16181, 43.2 mm SL. **J.** *Oligosarcus pintoii*, NUP 16165, 38.5 mm SL. **K.** *Piabina argentea*, NUP 16171, 59.2 mm SL. **L.** *Serrapinnus notomelas*, NUP 16177, 22.1 mm SL. **M.** *Characidium gomesi*, NUP 16179, 80.3 mm SL. **N.** *Characidium* aff. *zebra*, NUP 16144, 35.4 mm SL. **O.** *Cyphocharax modestus*, NUP 16142, 43.0 mm SL. **P.** *Steindachnerina brevipinna*, NUP 16155, 73.2 mm SL. **Q.** *Hoplerethrinus unitaeniatus*, NUP 16156, 192.1 mm SL. **R.** *Hoplias* sp. 3, NUP 16160, 113.2 mm SL. **S.** *Pyrrhulina australis*, NUP 16147, 26.1 mm SL. **T.** *Apareiodon affinis*, NUP 16183, 70.1 mm SL. **U.** *Parodon nasus*, NUP 16169, 74.3 mm SL. **V.** *Phalloceros harpagos*, NUP 16120, 26.8 mm SL (female, below., 19.2 mm SL (male, above. **W.** *Gymnotus inaequilabiatus*, NUP 16157, 122.2 mm SL. **X.** *Brachyhypopomus* aff. *gauderio*, NUP 16163, 129.1 mm SL. **Y.** *Cichlasoma paranaense*, NUP 16222, 82.2 mm SL. **Z.** *Crenicichla britskii*, NUP 16221, 102.3 mm SL. **A'.** *Pimelodella avanhandavae*, NUP 16139, 112 mm SL. **B'.** *Hypostomus ancistroides*, NUP 16184, 51.5 mm SL. **C'.** *Otothyropsis polyodon*, NUP 18972, 38.8 mm SL. **D'.** *Rineloricaria* sp., NUP 16170, 35.0 mm SL.

pelvic fin with 6–8, anal fin with 18–23, and caudal fin with 19, total rays (Lima 2003). Ground color silvery; no dark marks on body and fins. Reddish fins, except dorsal and adipose fins.

***Aphyocharax dentatus* Eigenmann & Kennedy, 1903**

*Aphyocharax dentatus* Eigenmann and Kennedy 1903: 516 [original description]—Britski et al. 1999: 45; Graça and Pavanelli 2007: 86, 88.

**Material examined.** Table 2; Figure 5B.

Elongated body; terminal mouth, slightly prognathous; premaxilla with 4–8 teeth, dentary with 9–23, and maxilla with 8–17 teeth. Lateral line incomplete, with 8–13 pored scales; longitudinal series with 36–42 scales.

Dorsal fin with 9–11, pectoral fin with 10–14, pelvic fin with 7–8, anal fin with 16–22, and caudal fin with 19, total rays (Lima 2003). Ground color silvery; diffuse, oval transversely elongated, humeral spot; no other dark marks on body and fin. Caudal fin red, other fins hyaline to yellowish.

***Astyanax* aff. *fasciatus* (Cuvier, 1819)**

*Chalceus fasciatus* Cuvier 1819: 352, pl. 26 [original description].

*Astyanax fasciatus*—Castro et al. 2004: 32, fig. 4a, 5.

*Astyanax* aff. *fasciatus*—Graça and Pavanelli 2007: 54, 57; Bifi et al. 2017: 4, 5, fig. 2.5

*Astyanax fasciatus*—Hoffmann et al. 2015: 4, fig. A1.G.

**Material examined.** Table 2; Figure 5C.



Elongated body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 4 or 5, dentary with 10–12, and maxilla with one tooth. Complete lateral line with 34–36 pored scales; transversal series above lateral line with 5 or 5½ scale rows and below with 5 scale rows. Dorsal fin with 11, pectoral fin with 15, pelvic fin with 9, anal fin with 24–28, and caudal fin with 19, total rays. Ground color silvery; dark vertically elongated humeral blotch; silvery longitudinal band on the flank (dark in fixed specimens) from humeral blotch to median caudal-fin rays, being larger on caudal peduncle and forming oval-shaped, horizontally elongated blotch. Reddish unpaired fins reddish and hyaline paired fins.

#### ***Astyanax aff. paranae* Eigenmann, 1914**

*Astyanax scabripinnis paranae* Eigenmann 1914: 47 [original description].

*Astyanax aff. paranae*—Graça and Pavanelli 2007: 54, 58; Bifi et al. 2017: 4, 5, fig. 2.7.

*Astyanax paranae*—Hoffmann et al. 2015: 4, fig. A1.H.

**Material examined.** Table 2; Figure 5D.

Elongated body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 4 or 5, dentary with 8–13, and maxilla with 1 tooth. Complete lateral line with 38 or 39 pored scales; transversal series above lateral line with 5 or 5½ scale rows and below with 4 or 4½ scale rows. Dorsal fin with 11, pectoral fin with 15 or 16, pelvic fin with 9, anal fin with 17–23 and caudal fin with 19, total rays. Ground color silvery; dark vertically elongated humeral blotch followed by another similar dark humeral blotch, smaller than the first. Reddish fins.

#### ***Astyanax lacustris* (Lütken, 1875)**

*Tetragonopterus lacustris* Lütken 1875: 131 [original description].

*Astyanax scabripinnis*—Castro et al. 2004: 32, fig. 4a, 4.

*Astyanax altiparanae*—Graça and Pavanelli 2007: 54, 55; Hoffmann et al. 2015: 4, fig. A1.E.

*Astyanax lacustris*—Lucena and Soares 2016: 103, figs. 1, 6, 8, 9; Bifi et al. 2017: 4, 5, fig. 2.6.

**Material examined.** Table 2; Figure 5E.

Deep body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 4 or 5, dentary with 8–16, and no maxillary teeth. Lateral line complete, with 33–41 pored scales; transversal series above lateral line with 6–8 scale rows and below with 4–8 scale rows. Dorsal fin with 12, pectoral fin with 12 or 13, pelvic fin with 8 or 9, anal fin with 22–34, and caudal fin with 19, total rays (Garutti and Britski 2000). Ground color silvery; 1 black rounded humeral blotch followed by another vertically elongated humeral blotch, silvery longitudinal band on the flank (dark in fixed specimens) from humeral blotch to median caudal-fin rays, being larger on caudal peduncle and forming oval-shaped, horizontally elongated blotch. Yellowish fins.

#### ***Piabarchus stramineus* Eigenmann, 1908**

*Bryconamericus stramineus* Eigenmann 1908: 105 [original description]—Castro et al. 2004: 32, fig. 4a–8; Graça and Pavanelli 2007: 60, 62; Hoffmann et al. 2015: 4, fig. A2.A.

*Piabarchus stramineus*—Thomaz et al. 2015: 20, fig. 10; Bifi et al. 2017: 4, 5, fig. 2.10.

**Material examined.** Table 2; Figure 5F.

Elongated body; terminal mouth; inner row of premaxilla with 4 teeth, outer row with 5 teeth; dentary with 9 or 10 teeth, and maxilla with 2 teeth. Lateral line with 36–38 pored scales; transversal series above lateral line with 4 rows and below with 3. Dorsal fin with 11 or 12, pectoral fin with 14 or 15, pelvic fin 9, anal fin with 20–22, and caudal with 19, total rays. Ground color silvery to yellowish; silvery longitudinal band (dark in preserved specimens), from humeral spot to caudal peduncle; black oval, vertically elongated, humeral spot. Caudal fin yellowish to orange; remaining fins hyaline, with dusky border *P. stramineus* is very similar to *Bryconamericus exodon* Eigenmann, 1907, except for its caudal-fin margin that is hyaline versus dark margin in the latter. *Piabarchus* was described by presenting a long anal fin and its origin opposite to/or slightly in front of the dorsal-fin origin. Recently, Thomaz et al. (2015) described the molecular phylogeny of the Stevardiinae and allocated *Bryconamericus stramineus* in *Piabarchus*. Therefore, *P. stramineus* can be distinguished from *P. analis* (Eigenmann, 1914) and from *P. torrenticola* Mahnert & Géry, 1988 by the origin of its anal fin being behind the dorsal-fin origin.

#### ***Knodus moenkhausii* (Eigenmann & Kennedy, 1903)**

*Poecilurichthys moenkhausii* Eigenmann and Kennedy 1903: 522 [original description].

*Knodus moenkhausii*—Graça and Pavanelli 2007: 66.

**Material examined.** Table 2; Figure 5G.

Elongated body; terminal mouth; inner row of premaxilla with 4, outer row with 4 or 5, dentary with 8 or 9 and maxilla with 2 or 3 teeth. Lateral line with 35–39 scales, transversal series above lateral line with 4½–5½ scales above and below with 3–4½ scale rows. Dorsal fin with 10, pectoral fin with 14 or 15, pelvic fin with 8 or 9, anal with 22–24, and caudal fin with 19, total rays. Ground color silvery to pale yellow; silvery longitudinal band (dark-brown in preserved specimens) from humeral spot to median caudal-fin rays; dark-brown crosswise elongated humeral spot. Yellowish fins but reddish during the reproductive period.

#### ***Moenkhausia australe* (Eigenmann, 1908)**

*Moenkhausia australe* Eigenmann 1908: 103 [original description].

*Moenkhausia sanctaefilomenae*—Reis et al. 2003: 150.

**Material examined.** Table 2; Figure 5H.

Deep body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 3 or 4, dentary with 9–12 and maxilla with 1 or 2 teeth. Lateral line complete, with 19–26 pored scales; longitudinal series with 24–26 scales; transversal series above lateral line with 4, 4½ or 5 scale rows and below with 3, 3½ or 4 scale rows. Dorsal fin with 11, pectoral fin with 11–13, pelvic fin with 8, anal fin

with 24–27 and caudal fin with 19, total rays. Ground color silvery; scales with dark-brown border, conferring reticulated pattern to body; 1 dark-brown humeral spot; anterior half of caudal peduncle with light area. Hyaline fins, except caudal fin. *Moenkhausia australe* is morphologically similar to *M. forestii* and *M. sanctaefilomenae*, but can be distinguished from them by having lateral line completely pored, rarely disrupted (vs lateral line incompletely pored, in *M. forestii* and *M. sanctaefilomenae*).

***Moenkhausia bonita* Benine, Castro & Sabino, 2004**

*Moenkhausia bonita* Benine et al. 2004: 68, fig. 1 [original description].  
*Hemigrammus marginatus*—Graça and Pavanelli 2007: 63.

**Material examined.** Table 2; Figure 5I.

Elongated body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 2–5, dentary with 4 and maxilla with 2 or 3 teeth. Lateral line complete, with 29–34 pored scales; transversal series above lateral line with 5 scale rows and below with 3 scale rows. Dorsal fin with 11, pectoral fin with 12–13, pelvic fin with 8, anal fin with 24–26 and caudal fin with 19, total rays (Benine et al. 2004). Ground color silvery to pale yellow; dark-brown longitudinal stripe from opercle (conspicuously from vertical through dorsal-fin origin) to median caudal-fin rays; distal portion of caudal-fin lobes equally dark brown.

***Oligosarcus pintoii* Campos, 1945**

*Oligosarcus pintoii* Campos 1945: 456, fig. 9 [original description]—  
Graça and Pavanelli 2007: 69, 70.

**Material examined.** Table 2; Figure 5J.

Deep body; terminal mouth terminal; premaxilla with 10–12 teeth, dentary with 10–18, and maxilla with 15–23 teeth. Lateral line complete, with 36–40 pored scales; transversal series above lateral line with 7–9 scale rows and below with 6–8 scale rows. Dorsal fin with 12, pectoral fin with 14–17, pelvic fin with 9, anal fin with 28–33 and caudal fin with 19, total rays (Menezes 1987). Ground color yellowish to silvery; black rounded humeral spot with diffuse dorsal and ventral extensions, followed by second, inconspicuous humeral spot; silvery longitudinal stripe on flank (dark in preserved specimens).

***Piabina argentea* Reinhardt, 1867**

*Piabina argentea* Reinhardt 1867: 50, fig. 1 [original description]—  
Graça and Pavanelli 2007: 71; Hoffmann et al. 2015: 4, fig. A2.E;  
Bifi et al. 2017: 4, fig. 2.11.

**Material examined.** Table 2; Figure 5K.

Elongated body; subterminal mouth; outer row of premaxilla with 2 or 3 teeth, median row with 2 and inner row with 4, dentary with 6 or 7 and maxilla with 2 or 3 teeth. Lateral line complete, with 37–39 pored scales; transversal series above lateral line with 5 scales above and below with 3 or 4 scale rows. Dorsal fin with 10, pectoral fin with 12–13, pelvic fin with 9, anal with 18–21, and caudal fin with 19, total rays (Vari and Harold 2001). Ground color silvery to pale yellow; black humeral spot,

with irregular limits; dark-brown longitudinal band, from humeral spot to median caudal-fin rays. Hyaline fins.

***Serrapinnus notomelas* (Eigenmann, 1915)**

*Cheirodon notomelas* Eigenmann 1915: 74 [original description].  
*Serrapinnus notomelas*—Graça and Pavanelli 2007: 93; Bifi et al. 2017: 4, fig. 2.12.

**Material examined.** Table 2; Figure 5L.

Elongated body; terminal mouth; premaxilla with 4 or 5, dentary with 6 or 7 and maxilla with 1 or 2 teeth. Lateral line incompletely pored, with 5–7 pored scales; longitudinal series with 30–34 scales; transversal series above lateral line with 3½ or 4 scale rows and below with 3 or 3½ scale rows. Dorsal fin with 10 or 11, pectoral fin with 12 or 13, pelvic fin with 8 or 9, anal fin with 19–24 and caudal fin with 19, total rays. Ground color whitish; dark brown diffuse longitudinal stripe on flank, from pseudotympanum to caudal peduncle; black rounded blotch on posterior portion of caudal peduncle and caudal-fin base, not extended to median caudal-fin rays. Dorsal fin with dark chromatophores along two unbranched and first branched rays and proximal half of remaining; pectoral, pelvic, anal and caudal fins yellowish.

Family Crenuchidae

***Characidium gomesi* Travassos, 1956**

*Characidium gomesi* Travassos 1956: 3, fig. 1 [original description]—  
Hoffmann et al. 2015: 4, fig. A2.F.

**Material examined.** Table 2; Figure 5M.

Elongated body; terminal mouth; premaxilla with 6 or 7, dentary with 8–10 and maxilla with no teeth. Isthmus without scales. Lateral line with 34 or 35 pored scales; transversal series above lateral line with 4 scale rows and below with 2 or 2½ scale rows. Dorsal fin with 11, pectoral fin with 11–13, pelvic fin and anal fin with 8 or 9, and caudal fin with 18, total rays. Ground color brown; 3 dark brown longitudinal stripes on dorsal region of body; dark brown stripe from tip of snout to orbit; dark brown longitudinal stripe on flank, from humeral spot caudal peduncle; dark brown transversal bars on flank, conspicuous on caudal peduncle; dark brown spot at base of median caudal-fin rays. Hyaline fins; dorsal fin with 2 dark brown oblique stripes; adipose fin with distal portion darkened; posterior half of pectoral, pelvic and anal-fin rays darkened; caudal fin with 2 dark-brown transversal bars.

***Characidium aff. zebra* Eigenmann, 1909**

*Characidium zebra* Eigenmann 1909: 38 [original description]—Hoffmann et al. 2015: 4, fig. A2.H.  
*Characidium aff. zebra*—Graça and Pavanelli 2007: 50, 51; Bifi et al. 2017: 4, fig. 2.13.

**Material examined.** Table 2; Figure 5N.

Elongated body; terminal mouth terminal; isthmus covered by scales; premaxilla with 9, dentary with 10 or 11 teeth and no maxillary teeth. Lateral line with 34–37



pored scales; transversal series above lateral line with 4 scale rows and below with  $3\frac{1}{2}$ –4 scale rows. Dorsal fin with 11, pectoral fin with 13 or 14, pelvic fin with 9, anal fin with 9 rays, and caudal fin with 18 or 19, total rays. Ground color pale yellow; dark-brown longitudinal stripe from humeral spot to caudal peduncle; 8 to 10 dark brown transversal bars on flank; black spot on the base of median caudal-fin rays; hyaline fins.

Family Curimatidae

***Cyphocharax modestus* (Fernández-Yépez, 1948)**

*Curimatorbis modestus* Fernández-Yépez 1948: 43, fig. 21 [original description].

*Cyphocharax modestus*—Graça and Pavanelli 2007: 31.

**Material examined.** Table 2, Figure 5O.

Deep body; terminal mouth; premaxilla, dentary and maxilla without teeth. Lateral line with 31–36 pored scales; transversal series above lateral line with  $5\frac{1}{2}$ –7 scale rows and below with  $4\frac{1}{2}$ –6 scale rows. Dorsal fin with 11 or 12, pectoral fin with 14–16, pelvic fin with 9 or 10, anal fin with 8 or 9 and caudal fin with 19, total rays (Vari 1992). Ground color silvery; dark brown inconspicuous longitudinal band along lateral line to distal margin of median caudal-fin rays, larger on caudal peduncle; hyaline fins.

***Steindachnerina brevipinna* (Eigenmann & Eigenmann, 1889)**

*Curimatus gilberti brevipinnis* Eigenmann and Eigenmann 1889: 424 [original description].

*Steindachnerina brevipinna*—Graça and Pavanelli 2007: 32, 33.

**Material examined.** Table 2; Figure 5P.

Elongated body; terminal mouth; premaxilla, dentary, and maxilla without teeth; palate with irregular glomerular projections. Lateral line with 33–37 pored scales; transversal series above lateral line with  $5\frac{1}{2}$ – $6\frac{1}{2}$  scale rows and below with  $4\frac{1}{2}$ – $5\frac{1}{2}$ . Dorsal fin with 10–12, pectoral fin with 11–14, pelvic fin with 9, anal fin with 9 or 10, and caudal fin with 19, total rays (Vari 1991). Ground color silvery; black conspicuous longitudinal stripe along lateral line to distal margin of median caudal-fin rays, larger on caudal peduncle; yellowish fins; dorsal-fin black blotch on the base of median rays, sometimes little conspicuous.

Family Erythrinidae

***Hoplerythrinus unitaeniatus* (Agassiz, 1829)**

*Hoplerythrinus unitaeniatus*—Graça and Pavanelli 2007: 10, 102, 233.

**Material examined.** Table 2; Figure 5Q.

Elongated and cylindrical body; terminal mouth; premaxilla with 8–10, dentary with 35–38, and maxilla with 32–36 teeth. Lateral line with 35–39 pored scales; transversal series above lateral line with  $3\frac{1}{2}$  scale rows and below with 3 scale rows. Dorsal fin with 11, pectoral fin with 14 or 15, pelvic fin with 8, anal fin with 13 or 14, and

caudal fin with 19, total rays. Brown ground color with dorsal regions darker than the ventral ones; dark brown rounded blotch on opercle; dark brown longitudinal band from opercle to caudal-fin base; dark fins; without adipose fin.

***Hoplias* sp. 3**

*Hoplias* sp. 3—Graça and Pavanelli 2007: 106.

**Material examined.** Table 2; Figure 5R.

Elongated body; terminal mouth; premaxilla with 8–10; dentary with 30–35; maxilla with 32–36 teeth. Lateral line with 40–42 pored scales; series between lateral lines with 113 scale rows. Dorsal fin with 13, pectoral fin with 13 or 14, pelvic fin with 8, anal fin with 8–11 rays and caudal fin with 19, total rays. Ground color pale brown; dark-brown longitudinal band, from opercle to caudal peduncle; several dark-brown irregular transversal bars. Fins with dark-brown spots, sometimes forming dark brown stripes parallel with fin base. This species is predatory to small fish. It lives in habitats structured mainly by macrophytes, exhibiting sedentary habits and parental care.

Family Lebiasinidae

***Pyrrhulina australis* Eigenmann & Kennedy, 1903**

*Pyrrhulina australe* Eigenmann and Kennedy 1903: 508 [original description].

*Pyrrhulina australis*—Graça and Pavanelli 2007: 107.

**Material examined.** Table 2; Figure 5S.

Elongated body; terminal mouth; inner row of premaxilla with 9–12 and outer row with 4–6 teeth, inner row of dentary with 8–12 and outer row with 4–5, and maxilla with 1 or 2 teeth. Lateral line absent; longitudinal series with 20–25 scales; transversal series with 6–8 scale rows. Dorsal fin with 9 or 10, pectoral fin with 11 or 12, pelvic fin with 9 or 10, anal fin with 10 or 11, and caudal fin with 19, total rays. Ground color pale brown; dark brown longitudinal stripe from the anterior portion of the dentary, through orbit, to opercle; yellowish fins; black irregular blotch on the dorsal fin. Some specimens can present few or many dark blotches on body.

Family Parodontidae

***Apareiodon affinis* (Steindachner, 1879)**

*Parodon affinis* Steindachner 1879: 20 [original description].

*Apareiodon affinis*—Graça and Pavanelli 2007: 26, 27.

**Material examined.** Table 2; Figure 5T.

Elongated body; subterminal mouth; premaxilla with 4 or 5, maxilla with 2 or 3 and dentary with no teeth. Lateral line with 39–46 pored scales; transversal series above lateral line with  $4\frac{1}{2}$  or 5 scale rows and below with 3 or  $4\frac{1}{2}$  scale rows. Dorsal fin with 10–13, pectoral fin with 11–14, pelvic fin with 7–9, anal fin with 7 or 8 rays and caudal fin with 18 or 19, total rays (Pavanelli 1999). Ground color silvery to pale yellow; black longitudinal band along lateral line, from opercle to median caudal-

fin rays, without adjacent dark blotches downwards; 6–8 dark brown transversal bars above longitudinal band; hyaline fins or with few scattered dark cromathophores.

***Parodon nasus* Kner, 1859**

*Parodon nasus* Kner 1859: 167, fig. 17 [original description]—Graça and Pavanelli 2007: 30; Bifi et al. 2017: 4, fig. 2.2.

**Material examined.** Table 2; Figure 5U.

Elongated body; subterminal mouth; premaxilla with 4, dentary with 2–4 and maxilla with 2 teeth. Lateral line with 35–39 pored scales; transversal series above lateral line with 4½ scale rows and below with 3 or 3½ scale rows. Dorsal fin with 11 or 12, pectoral fin with 13–16, pelvic fin with 8 or 9, anal fin with 8 or 9 and caudal fin with 19, total rays (Pavanelli 1999). Ground color pale brown dorsally and pale yellow ventrally; black longitudinal band along lateral line, from opercle to median caudal-fin rays, with projections upwards and downwards, conferring zigzag pattern; hyaline or yellowish fins.

Order Cyprinodontiformes

Family Poeciliidae

***Phalloceros harpagos* Lucinda, 2008**

*Phalloceros* sp. n.—Lucinda and Reis 2005.

*Phalloceros* aff. *caudimaculatus*—Graça and Pavanelli 2007: 196.

*Phalloceros harpagos* Lucinda 2008: 134, 135; fig. 27 [original description]—Hoffmann et al. 2015: 4, fig. A5.A; Bifi et al. 2017: 4, fig. 2.27.

**Material examined.** Table 2; Figure 5V.

Elongated body; superior mouth, dentary prognathous; premaxilla and dentary with several small teeth. Longitudinal series with 26–32 scales and transversal series with 7–9 scale rows. Dorsal fin with 7–9, pectoral fin with 11–13, pelvic fin with 5 or 6, and anal fin with 8–10 (males) or 10–12 rays (females) (Lucinda 2008). Adult males with gonopodium. Ground color yellowish-brown; dark brown vertically elongated lateral spot; scales with dark brown border, conferring a reticulate pattern to the body.

Order Gymnotiformes

Family Gymnotidae

***Gymnotus inaequilabiatus* (Valenciennes, 1839)**

*Carapoz inaequilabiatus* Valenciennes (1839): 14 [original description].

*Gymnotus inaequilabiatus*—Graça and Pavanelli 2007: 178, 179; Bifi et al. 2017: 4, 6, fig. 2.26.

**Material examined.** Table 2; Figure 5W.

Elongated and compressed body; superior mouth, dentary prognathous; one or two conical teeth on the premaxilla and dentary. Transversal series above lateral line with 6–8 scale rows. Pectoral fin with 13–16 and anal fin with 170–260, total rays. Ground color pale brown; body with light transversal bars alternating with dark brown transversal bars, visible in specimens with less than 250

mm total length (TL); in larger specimens stripes can be broken or disappear, resulting in color pattern with dark-brown rounded or irregular blotches, especially on dorsal region of body; dark-brown bars wider than light bars. Hyaline fins, with scattered dark-brown spots. Body with 21 or 22 pairs of obliquely dark bands from the tail tip to nape. Pectoral and anal fins are uniformly dark gray, and the posterior part of the anal fin is pale.

***Gymnotus pantanal* Fernandes, Albert, Daniel-Silva, Lopes, Crampton & Almeida-Toledo, 2005**

*Gymnotus pantanal* Fernandes et al. 2005: 4, Fig. 1 [original description]—Graça and Pavanelli 2007: 178, 180.

**Material examined.** Table 2

Elongated and subcylindrical body; superior mouth, dentary prognathous. Pectoral fin with 16–18 and anal fin with 256–270, total rays; transversal series above lateral line with 7 or 8 scale rows (Fernandes et al. 2005). Ground color brown; body with seven to 25 light transversal stripes, spaced apart; hyaline fins or light, with scattered dark brown spots.

Family Hypopomidae

***Brachyhypopomus* aff. *gauderio* Giora & Malabarba, 2009**

*Brachyhypopomus* sp.—Giora et al. 2008: 167.

*Brachyhypopomus* cf. *pinnicaudatus*—Graça and Pavanelli 2007: 188.

*Brachyhypopomus gauderio* Giora and Malabarba 2009: 63, 64, Figs. 1, 2 [original description].

**Material examined.** Table 2; Figure 5X.

Elongated and compressed body; terminal mouth. Pectoral fin with 14–17 and anal fin with 179–226, total rays; transversal series above lateral line with 7 or 8 scale rows (Giora and Malabarba 2009). Ground color varies from yellowish to pale brown; dorsal region and lower half of the body with dark brown transversal and irregular bars; anal fin is hyaline with dark brown spots.

Family Sternopygidae

***Eigenmannia guairaca* Peixoto, Dutra & Wosiacki, 2015**

*Eigenmannia guairaca* Peixoto et al. (2015): 394, Fig. 9 [original description].

**Material examined.** Table 2.

Elongated and compressed body; terminal mouth; premaxilla with 9 or 10 teeth distributed in two rows. Lateral line complete, with 110–143 pored scales; transversal series above lateral line with 9–11 scale rows. Pectoral fin with 12 or 13 and anal fin with 151–170, total rays (Peixoto et al. 2015). Ground color pale brown; four dark-brown longitudinal stripes on flank (one superior medial, one lateral line, one inferior medial and one at anal-fin base).

Order Cichliformes

Family Cichlidae

***Cichlasoma paranaense* Kullander, 1983**

*Cichlasoma paranaense* Kullander 1983: 241, Fig. 1 [original description]—Graça and Pavanelli 2007: 203; Bifi et al. 2017: 4, Fig. 2.29.

**Material examined.** Table 2; Figure 5Y.

Deep body; terminal mouth; premaxilla with 2 or 3 and dentary with 3 or 4 teeth rows. Upper lateral line with 14–17 pored scales, lower lateral line with 5–8 pored scales and longitudinal series with 22–23 scales. Transversal series above upper lateral with 2½–4 and below lower lateral line with 5–7 scale rows. Dorsal fin with XIII–XV, 10–15, pectoral fin with 12–13, pelvic fin with I,6 and anal fin with III, 8–10 total rays (Kullander 1983). Ground color iridescent green; dark brown transversal bars; dark-brown rounded blotch, slightly below upper lateral line; dark brown blotch on superior portion of caudal peduncle.

***Crenicichla britskii* Kullander, 1982**

*Crenicichla britskii* Kullander 1982: 642, fig. 7 [original description]—Graça and Pavanelli 2007: 204, 205; Bifi et al. 2017: 4, fig. 2.30.

**Material examined.** Table 2; Figure 5Z.

Elongated body; terminal mouth; premaxilla and dentary with arranged in several teeth rows. Upper lateral line with 20–22 pored scales, lower lateral line with 7–9 pored scales and longitudinal series with 33–40 scales. Transversal series above upper lateral with 3–4½ and below lower lateral line with 7–9 scale rows. Dorsal fin with XVI, 14–16, pectoral fin with 14 or 15, pelvic fin with I,5 and anal fin with III, 9–11 total rays (Kullander, 1983). Ground color greyish to greenish; dorsum with dark transversal bars; dark suborbital stripe; dark brown discontinuous longitudinal band, sometimes inconspicuous, from snout to caudal peduncle; black rounded humeral blotch; black rounded ocelli on caudal-fin base. Dorsal, anal and caudal fins with light spots; pectoral and pelvic fins yellowish or hyaline.

Order Siluriformes

Family Auchenipteridae

***Trachelyopterus galeatus* (Linnaeus, 1766)**

*Parauchenipterus galeatus*—Graça and Pavanelli 2007: 175.

*Trachelyopterus galeatus*—Costa et al. 2017: 44, fig. 2C.

**Material examined.** Table 2

Deep body; terminal mouth terminal with dentigerous tooth plates in both premaxilla and dentary. Dorsal fin with I,6, pectoral fin with I,7, pelvic fin with 7 or 8 and anal fin with 21–24, total rays. Adipose fin present. Ground color pale yellow to orange with several dark-brown irregular blotches as well as fins.

Family Callichthyidae

***Callichthys callichthys* (Linnaeus, 1758)**

*Callichthys callichthys*—Graça and Pavanelli 2007: 112; Hoffmann et al. 2015: 4, fig. A3.I.

**Material examined.** Table 2.

Elongated body; terminal mouth. Lateral line with 4 pores on upper series of plates. Dorsolateral series with 26–29 and ventrolateral series with 24–27 plates. Dorsal fin with I,7 or 8, pectoral with I,6, pelvic and anal fins with 6, total rays. Ground color pale brown to dark grey; dark fins with dark spots. Coracoid bone, between pectoral fins, covered by skin.

***Corydoras aeneus* (Gill, 1858)**

*Hoplosoma aeneum* Gill 1858: 403 [original description].

*Corydoras aeneus*—Graça and Pavanelli 2007: 113; Hoffmann et al. 2015: 4, fig. A3.J; Bifi et al. 2017: 4, fig. 2.19.

**Material examined.** Table 2.

Deep body deep and elliptical; inferior mouth. Lateral line with 4–6 pores on upper series of plates. Dorsolateral series with 20–23 and ventrolateral series with 19–22 plates. Dorsal fin with I,7 or 8, pectoral with I,8–10, pelvic fin with 6 and anal fin with 6–8, total rays. Ground color dark grey dorsally and yellowish ventrally; large dark regular spot in anterior region of flank; dark fins, without spots. Coracoid bones exposed; maxillary barbel short, not reaching pectoral-fin base; dorsal-fin spine approximately the same size as its first unbranched ray.

***Hoplosternum littorale* (Hancock, 1828)**

*Callichthys littoralis* Hancock 1828: 244, pl. 32, fig. 1 [original description].

*Hoplosternum littorale*—Graça and Pavanelli 2007: 115.

**Material examined.** Table 2.

Elongated body; terminal mouth. Lateral line with 4–6 pores on upper series of plates. Dorsolateral series with 25–27 and ventrolateral with 22–24 plates. Dorsal fin with I,7, pectoral with I,9 or 10, pelvic fin with 6 and anal fin with 8, total rays (Reis 1997). Ground color dark gray, lighter ventrally; dark fins. Coracoid bone exposed; maxillary barbel long, surpassing gill opening; dorsal-fin spine short, smaller than half of its first unbranched ray; caudal fin bifurcated; maxillary barbel not reaching pelvic-fin base.

Family Heptapteridae

***Imparfinis schubarti* (Gomes, 1956)**

*Nannorhamdia schubarti* Gomes 1956: 404, fig. 1 [original description].

*Imparfinis schubarti*—Graça and Pavanelli 2007: 142, 144.

**Material examined.** Table 2.

Elongated body; terminal mouth; premaxilla and dentary with several diminute and viliform teeth. Dorsal fin with 7, pectoral fin with 8–11, pelvic fin with 6 and anal fin with 11–14, total rays. First dorsal fin ray shorter than the second one; adipose-fin base short, not extending to caudal fin. Ground color beige; few scattered dark brown on body, except on ventral region of head and abdomen; dark brown transversal bars on dorsum; dark brown conspicuous longitudinal stripe along lateral line; yellowish or hyaline fins.



***Pimelodella avanhandavae* Eigenmann, 1917**

*Pimelodella avanhandavae* Eigenmann 1917: 240, pl. 29; fig. 3 [original description]—Graça and Pavanelli 2007: 145, 146.

**Material examined.** Table 2; Figure 5A'.

Elongated body; terminal mouth; premaxilla and dentary with several small and villiform teeth. Dorsal fin with I,6; pectoral fin with I,9 or 10; pelvic fin with 6 and anal fin with 12–14, total rays. Ground color beige; 2 dark brown longitudinal bands, 1 along the lateral line and another slightly below the dorsal fin; light fins.

***Pimelodella gracilis* (Valenciennes, 1835)**

*Pimelodus gracilis* Valenciennes 1835: pl. 2, fig. 5 [original description].

*Pimelodella gracilis*—Graça and Pavanelli 2007: 145, 147; Hoffmann et al. 2015: 4, fig. A3.B.

**Material examined.** Table 2.

Elongated body; terminal mouth; premaxilla and dentary with several diminute and viliform teeth. Dorsal fin with I,6, pectoral fin with I,9 or 10, pelvic fin with 6 and anal fin with 12–14, total rays. Ground color beige; dark brown longitudinal band along lateral line; light fins.

***Rhamdia quelen* (Quoy & Gaimard, 1824)**

*Rhamdia quelen*—Graça and Pavanelli 2007: 149; Hoffmann et al. 2015: 4, fig. A3.C; Bifi et al. 2017: 4, fig. 2.16.

**Material examined.** Table 2.

Elongated body; terminal mouth; premaxilla and dentary with several diminute and viliform teeth. Dorsal fin with 7, pectoral fin with 8–10, pelvic fin with 6 and anal fin with 14–15, total rays. Ground color beige to brown; some specimens can present scattered dark brown chromatophores on body; dark fins.

Family Loricariidae

***Farlowella hahni* Meinken, 1937**

*Farlowella hahni* Meinken 1937: 77, fig. 2 [original description].

*Farlowella* aff. *amazona*—Graça and Pavanelli 2007: 119.

**Material examined.** Table 2.

Depressed body; inferior mouth; premaxilla with 15–17 and dentary with 13–18 teeth. Mid-lateral series with 32, predorsal series with 7, series between pectoral and pelvic fins with 5 and abdomen series with 3 plates. Dorsal and pectoral fins with I,6, pelvic fin with i,4 or 5 and anal with 6, total rays. Ground color brown; dark brown longitudinal band from base of snout to caudal peduncle; hyaline fins with few dark brown spots, caudal fin with discontinuous dark brown longitudinal band in upper lobe.

***Hypostomus iheringii* (Regan, 1908)**

*Plecostomus iheringii* Regan 1908: 795, pl. 47, fig. 1 [original description].

*Hypostomus* sp.—Graça and Pavanelli 2007: 136.

**Material examined.** Table 2.

Deep body; inferior mouth; teeth bifid; premaxilla with 32–41 and dentary with 35–42 teeth. Mid-lateral series with 24–27 plates, predorsal series with 3, and dorsal-fin base series with 8 plates. Dorsal fin with I,7, pectoral fin with I,6, pelvic fin with i,5, and anal fin with 6, total rays. Ground color brownish; dark brown blotches, occasionally inconspicuous.

***Hypostomus ancistroides* (Ihering, 1911)**

*Plecostomus ancistroides* Ihering 1911: 396 [original description].

*Hypostomus ancistroides*—Oyakawa et al. 2005: 4, 10, 11, 12; fig. 4; Graça and Pavanelli 2007: 126, 128; Hoffmann et al. 2015: 4, fig. A4.C; Bifi et al. 2017: 4, fig. 2.22.

**Material examined.** Table 2; Figure 5B'.

Deep body; inferior mouth; teeth bifid; premaxilla with 24–33 and dentary with 23–35 teeth. Mid-lateral series with 27 or 28 plates, predorsal series with 3, and dorsal-fin base series with 8 or 9 plates. Dorsal fin with I,7; pectoral fin with I,6; pelvic fin with i,5; and anal fin with 6, total rays. Brown ground color; dark brown blotches on body, especially on the dorsal region; dark fins with dark brown spots.

***Hypostomus strigaticeps* (Regan, 1908)**

*Plecostomus strigaticeps* Regan 1908: 796, pl. 48, fig. 1 [original description].

*Hypostomus* cf. *strigaticeps*—Graça and Pavanelli 2007: 126, 134.

*Hypostomus strigaticeps*—Hoffmann et al. 2015: 4, fig. A4.E; Bifi et al. 2017: 4, fig. 2.23.

**Material examined.** Table 2.

Deep body; inferior mouth; teeth bifid; premaxilla with 49–54 and dentary with 49–55 teeth. Mid-lateral series with 24–26 plates, predorsal series with 3, and dorsal-fin base series with 8 plates; abdomen with plates concentrated on its central portion. Dorsal fin with I,7, pectoral fin with I,6, pelvic fin with i,5 and anal fin with 6, total rays. Ground color brown; light blotches on body, smaller on head; dark fins with light spots.

***Otothyropsis polyodon* Calegari, Lehmann & Reis, 2013**

*Otothyropsis polyodon* Calegari et al. 2013: 133, fig. 3 [original description].

**Material examined.** Table 2, Figure C'.

Elongated body; inferior mouth; premaxilla and dentary with 14–21 teeth. Lateral line series with 24 or 25 plates. Dorsal fin with I,7, rarely 8, pectoral fin with I,6, pelvic fin with 6 and anal fin with 6, total rays (Calegari et al. 2013). Ground color brown; dark brown longitudinal stripe from snout to caudal fin; hyaline fins, with dark brown spots; upper caudal-fin lobe with dark brown spot close to its tip; lower caudal-fin lobe dark, with hyaline portion on its lower portion, frequently with small dark brown spots.

***Rineloricaria* sp.**

*Rineloricaria* sp.—Graça and Pavanelli 2007: 124.

**Material examined.** Table 2, Figure D'.

Depressed body; inferior mouth; premaxilla and dentary with 6 teeth. Mid-lateral series with 28 plates. Dorsal fin with I,7, pectoral fin with I,6, pelvic fin with i,5 and anal with 6 total rays. Ground color brownish; dark brown transversal bars on flank; hyaline fins with few dark brown spots, sometimes forming irregular stripes.

## Discussion

The taxonomic composition of the 3 studied streams was not different from the pattern described for the South America freshwater fish fauna, given the predominance of Characiformes and Siluriformes orders (Albert et al. 2011, Hulsey and López-Fernández 2011), which included 83% of the captured species. In addition, the record of 18 of the 34 families listed by Buckup (1999) for Brazilian streams draws attention to the high richness of the Iguatemi river fish fauna, considering that only 3 streams were sampled. The families with the highest number of species in our study (Characidae, Heptapteridae, and Loricariidae) were also reported by Langeani et al. (2007) as the most species-rich in the upper Paraná river basin. Similarly, several studies have indicated the prevalence of these families in other streams of this basin (Casatti et al. 2001, Cunico et al. 2009, Suárez and Lima-Júnior 2009, Felipe and Suárez 2010, Pereira et al. 2014, Frota et al. 2016, Bifi et al. 2017). In addition, the most representative species in number of individuals, *P. harpagos*, *A. aff. paranae*, *H. ancistroides*, *G. inaequilabiatus*, and *K. moenkhausii*, were also numerically important in other surveys conducted in streams of the upper Paraná river basin (Casatti et al. 2001, Castro et al. 2004, Casatti 2005, Ferreira 2007, Daga et al. 2012, Mendonça et al. 2014).

It is also important to emphasize that the species richness of Água Boa and Santa Maria streams (both with 31 species) are well above those recorded in other streams of the upper Paraná river basin (see Casatti 2004, Rocha et al. 2009, Felipe and Suárez 2010), even including pristine streams (see Casatti et al. 2001). This finding once again highlights the role of the Iguatemi river basin in harboring a diverse fish fauna in its streams. In fact, the number of species recorded in the three streams inventoried here, accounts for 29% of the representativeness of ichthyofauna of the upper Paraná River floodplain presented by Graça and Pavanelli (2007), and 15% of the species of the Mato Grosso do Sul state recorded by Froehlich et al. (2017). Therefore, we advocate that the sampled area is intimately associated with maintaining the biodiversity of fish species in the floodplain, serving as refuges, and encompassing a good percentage of fish species of the state within a small area.

The high fish species richness of streams could be related to 3 main factors. The first concerns about the small body size of individuals inhabiting streams; the speciation rate is assumed to be inversely related to body size (Marzluff and Dial 1991, Brown 1995). These habitats may contain more niches for small organisms than

large ones; therefore, in principle, small-bodied species would be less prone to extinction (Purvis et al. 2003). The second factor is related to the environmental complexity of streams (Castro et al. 2003, Copatti and Copatti 2011) as the mosaic of pools, runs, and riffles clearly delimit different combinations of flow, depth, and substrate (Angermeier and Schlosser 1989); thus, it is expected that every mesohabitat hold unique species given the resources and conditions available. The third factor has to do with the degree of conservation of riparian vegetation, as fish species richness is positively associated with surrounding vegetation integrity (Ferreira and Casatti 2006). The deleterious effects caused by the removal of this vegetation bordering streams include: increased solar radiation and consequent rise in water temperature, reducing fish tolerance to toxic gases such as ammonia; development of toxic Cyanophyceae; the silting-up of the bed; reduced leaf, trunk, and branch inputs that shelter and provide substrate for the development of organisms consumed by the fish (Pusey and Arthington 2003, Casatti 2010). These impacts can substantially alter the composition and abundance of fish assemblages inhabiting streams (Agostinho et al. 2007, Casatti et al. 2010). Whereas the riparian vegetation surrounding these streams is poor, due to anthropogenic action, the fish assemblages may already be under such deleterious effects.

This conception of constancy of species can illustrate the spatial occupation of fish assemblages (Begon et al. 2007), discriminating migrant and resident populations (Dajoz 1983, Langeani et al. 2005). The greatest number of accessory and occasional species recorded in Água Boa and Santa Maria suggests a high exchange of species between these streams and Iguatemi River, as long as fish may use these environments in the search for resources. Suárez and Petrere-Júnior (2006) drew similar inferences for Jogui region, Iguatemi river basin and Viana et al. (2013) for Bonito region, Ivaí river basin.

In addition, the fish fauna of the sampled streams was primarily composed of autochthonous species, following the pattern described for the species of the upper Paraná River (Langeani et al. 2007). Regarding the 5 allochthonous species, we may report that *K. moenkhausii* and *S. brevipinna* reached the upper Paraná river basin after the construction of Itaipu Reservoir (Júlio-Júnior et al. 2009). In turn, *B. aff. gauderio* and *H. unitaeniatus* were introduced by fishing activities, possibly as live bait, while the origin of *G. inaequilabiatus* in the basin is unknown (Langeani et al. 2007). Therefore, the presence of these 5 species in the streams highlights their dispersal abilities and success in the occupation of low order rivers.

In general, our study shows that streams of the lower portion of the Iguatemi river basin encompass a diverse fish fauna, in contrast to the anthropogenic impacts affecting the microbasins. This calls the attention to the urgency of primary management measures in the studied microbasins, such as the implementation and/or extension of soil conservation practices and riparian vegetation restoration, to help the maintenance of fish populations.



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## Authors' Contributions

All authors contributed to the drafting and editing of the manuscript. AF took the photographs. WJG identified the specimens. VFBS, EALK, and MCFA participated in the data collection.

## References

- Agostinho AA, Gomes LC, Pelicice FM (2007) Ecologia e manejo de recursos pesqueiros em reservatórios do Brasil. EDUEM, Maringá, 501 pp.
- Agostinho AA, Bonecker CC, Gomes LC (2009) Effects of water quantity on connectivity: the case of the upper Paraná River floodplain. *Ecohydrology Hydrobiology* 9: 99–113. <https://doi.org/10.2478/v10104-009-0040-x>
- Albert J, Petry P, Reis RE (2011) Major biogeographic and phylogenetic patterns. In: Albert JS, Reis RE (Eds) *Historical biogeography of Neotropical freshwater fishes*. University of California Press, Berkeley, 21–56.
- Angermeier PL, Schlosser IJ (1989) Species-area relationship for stream fishes. *Ecology* 70: 450–462.
- Begon M, Townsend CR, Harper JR (2007) *Ecologia: de indivíduos a ecossistemas*. Artmed, Porto Alegre, 752 pp.
- Benine RC, Castro RMC, Sabino J (2004) *Moenkhausia bonita*: a new small characin fish from the Rio Paraguay basin, southwestern Brazil (Characiformes: Characidae). *Copeia* 2004: 68–73. <https://doi.org/10.1643/CI-03-008R1>
- Betancur-R R, Wiley EO, Arratia G, Acero A, Bailly N, Miya M, Lecointre G, Ortí G (2017) Phylogenetic classification of bony fishes. *BMC Evolutionary Biology* 17: 162. <http://doi.org/10.1186/s12862-017-0958-3>
- Bifi AG, Dias AC, Frota A (2017) Fish species (Osteichthyes: Actinopterygii) from two tributaries of the Rio do Peixe basin, Tupã municipality, São Paulo state, Brazil. *Check List* 13: 2063. <https://doi.org/10.15560/13.2.2063>
- Bloch ME (1794) *Naturgeschichte der ausländischen Fische*, vol. 8. Berlin. iv + 174 pp., pls. 361–396.
- Britski HA, Silimon KZS, Lopes BS (1999) *Peixes do Pantanal: manual de identificação*. Embrapa, Brasília, 184 pp.
- Brown JH (1995) *Macroecology*. University of Chicago Press, Chicago, 270 pp.
- Buckup PA (1999) Sistemática e biogeografia de peixes de riachos. In: Caramaschi EP, Mazzoni R, Bizerril CRSF, Peres-Neto PR (Eds) *Ecologia de peixes de riachos. Série Oecologia Brasiliensis, Computer and Publish Editoração, Rio de Janeiro*, 91–138.
- Calegari BB, Lehmann AP, Reis RE (2013) Two new species of cascudinhos of the genus *Otothyropsis* (Siluriformes: Hypoptopomatinae) from the rio Paraná basin, Brazil. *Zootaxa* 3619: 130–144. <https://doi.org/10.11646/zootaxa.3619.2.2>
- Campos AA (1945) *Sobre os Caracídeos do Rio Mogi-guaçu (Estado de São Paulo)*. *Arquivos de Zoologia (São Paulo)* 4: 431–466.
- Casatti L (2004) Ichthyofauna of two streams (silted and reference) in the upper Paraná River basin, southeastern Brazil. *Brazilian Journal of Biology* 64: 757–765. <https://doi.org/10.1590/S1519-69842004000500004>
- Casatti L (2005) Fish assemblage structure in a first order stream, South-eastern Brazil: longitudinal distribution, seasonality and micro-habitat diversity. *Biota Neotropica* 5: 1–9. <https://doi.org/10.1590/S1676-06032005000100009>
- Casatti L (2010) Alterações no Código Florestal Brasileiro: impactos potenciais sobre a ictiofauna. *Biota Neotropica* 10: 31–34. <https://doi.org/10.1590/S1676-06032010000400002>
- Casatti L, Langeani F, Castro RMC (2001) Peixes de riacho do Parque Estadual Morro do Diabo, bacia do alto rio Paraná, SP. *Biota Neotropica* 1: 1–15. <https://doi.org/10.1590/S1676-06032001000100005>
- Casatti L, Romero RM, Teresa FB, Sabino J, Langeani F (2010) Fish community structure along a conservation gradient in Bodoquena plateau streams, central west of Brazil. *Acta Limnologica Brasiliensis* 22: 50–59. <https://doi.org/10.4322/actalb.02201007>
- Castro RMC (1999) Evolução da ictiofauna de riachos sul-americanos: padrões gerais e possíveis processos causais. In: Caramaschi EP, Mazzoni R, Bizerril CRSF, Peres-Neto PR (Eds) *Ecologia de peixes de riachos. Série Oecologia Brasiliensis, Computer and Publish Editoração, Rio de Janeiro*, 139–155.
- Castro RMC, Casatti L, Santos HF, Ferreira KM, Ribeiro AC, Benine RC, Dardis GZP, Melo ALA, Stopiglia R, Abreu TX, Bockmann FA, Carvalho M, Gibran FZ, Lima FCT (2003) Estrutura e composição da ictiofauna de riachos do rio Paranapanema, Sudeste do Brasil. *Biota Neotropica* 3: 1–31. <https://doi.org/10.1590/S1676-06032003000100007>
- Castro RMC, Casatti L., Santos HF, Melo ALA, Martins LSF, Ferreira KM, Gibran FZ, Benine RC, Carvalho M, Ribeiro AC, Abreu TX, Bockmann FA, Pelício GZ, Stopiglia R, Langeani F (2004) Estrutura e composição da ictiofauna de riachos da bacia do rio Grande no estado de São Paulo, sudeste do Brasil. *Biota Neotropica* 3: 1–39. <http://doi.org/b2sg>
- Copatti CE, Copatti BR (2011) Variação sazonal e diversidade de peixes do rio Cambará, bacia do rio Uruguai. *Biota Neotropica* 11: 265–271. <https://doi.org/10.1590/S1676-06032011000400023>
- Costa, NKR, Paiva REC, Silva MJ, Ramos TPA, Lima SMQ (2017) Ichthyofauna of Ceará-Mirim River basin, Rio Grande do Norte state, northeastern Brazil. *ZooKeys* 715: 39–51. <https://doi.org/10.3897/zookeys.715.13865>
- Cunico AM, Graça WJ, Agostinho AA, Domingues WM, Latini JD (2009) Fish, Maringá urban streams, Pirapó river drainage, upper Paraná river basin, Paraná state, Brazil. *Check List* 5: 273–280. <https://doi.org/10.15560/5.2.273>
- Cuvier G (1819) Sur les poissons du sous-genre Hydrocyon, sur deux nouvelles espèces de Chalceus, sur trois nouvelles espèces du Serrasalmes, et sur l'Argentina glossodonta de Forskahl, qui est l'*Albula gonorrhynchus* de Bloch. *Mémoires du Muséum National d'Histoire Naturelle* 5: 351–379.
- Daga VS, Gubiani ÉA, Cunico AM, Baumgartner G (2012) Effects of abiotic variables on the distribution of fish assemblages in streams with different anthropogenic activities in southern Brazil. *Neotropical Ichthyology* 10: 643–652. <https://doi.org/10.1590/S1679-62252012000300018>
- Dajoz R (1983). *Ecologia geral*. Vozes, Petrópolis, 472 pp.
- Eigenmann CH, Eigenmann RS (1889) A revision of the edentulous genera of Curimatinae. *Annals of the New York Academy of Sciences* 4: 409–440.
- Eigenmann CH, Kennedy CH (1903) On a collection of fishes from Paraguay, with a synopsis of the American genera of cichlids. *Proceedings of the Academy of Natural Sciences of Philadelphia* 55: 497–537.
- Eigenmann CH (1908) Preliminary descriptions of new genera and species of tetragonopterid characins. (Zoological Results of the Thayer Brazilian expedition). *Bulletin of the Museum of Comparative Zoology* 52: 91–106.



- Eigenmann CH (1909) Reports on the expedition to British Guiana of the Indiana University and the Carnegie Museum, 1908. Report no. 1. Some new genera and species of fishes from British Guiana. *Annals of the Carnegie Museum* 6: 4–54.
- Eigenmann CH (1914) Some results from studies of South American fishes. IV. New genera and species of South American fishes. *Indiana University Studies* 20: 44–48.
- Eigenmann CH (1915) The Cheirodontinae, a subfamily of minute characid fishes of South America. *Memoirs of the Carnegie Museum* 7: 1–99.
- Eigenmann CH (1917) *Pimelodella* and *Typhlobagrus*. *Memoirs of the Carnegie Museum* 7: 229–258.
- Felipe TRA, Suárez YR (2010) Caracterização e influência dos fatores ambientais nas assembleias de peixes de riachos em duas micro-bacias urbanas, alto rio Paraná. *Biota Neotropica* 10: 143–151. <https://doi.org/10.1590/S1676-06032010000200018>
- Fernandes FMC, Albert JS, Daniel-Silva MDFZ, Lopes CE, Crampton WGR, Almeida-Toledo LF (2005) A new *Gymnotus* (Teleostei: Gymnotiformes: Gymnotidae) from the Pantanal Matogrossense of Brazil and adjacent drainages: continued documentation of a cryptic fauna. *Zootaxa* 933: 1–14. <https://doi.org/10.11646/zootaxa.933.1.1>
- Fernández-Yépez (1948) Los curimatidos (peces fluviales de Sur América). *Catalogo descriptivo con nuevas adiciones genericas y especificas. Boletín Taxonómico—Ministerio de Agricultura y Cría. Laboratorio de Pesquería. (no. 1). Caiguire, Venezuela. No. 1: 1–79 + table + index.*
- Ferraris CJ (2007) Checklist of catfishes, recent and fossil (Osteichthyes: Siluriformes), and catalogue of siluriform primary types. *Zootaxa* 1418: 1–628. <https://doi.org/10.11646/zootaxa.1418.1.1>
- Ferreira K (2007) Biology and ecomorphology of stream fishes from the rio Mogi-Guaçu basin, southeastern Brazil. *Neotropical Ichthyology* 5: 311–326. <https://doi.org/10.1590/S1679-62252007000300012>
- Ferreira CP, Casatti L (2006) Integridade biótica de um córrego na bacia do alto rio Paraná avaliada por meio da comunidade de peixes. *Biota Neotropica* 6: 1–25. <https://doi.org/10.1590/S1676-06032006000300002>
- Fitzpatrick FA, Waite IR, D’arconte PJ, Meador MR, Maupin MA, Gurtz ME (1998) Revised methods for characterizing stream habitat in the national water-quality assessment program. U.S. Geological Survey Water-Resources Investigations Report, Raleigh, 67 pp.
- Froehlich O, Cavallaro M, Sabino J, Suárez YR, Vilela MJA (2017) Checklist da ictiofauna do Estado de Mato Grosso do Sul, Brasil. *Iheringia* 107: e2017151. <https://doi.org/10.1590/1678-4766e2017151>
- Frota A, Deprá GC, Petenucci LM, Graça WJ (2016) Inventory of the fish fauna from Ivaí river basin, Paraná state, Brazil. *Biota Neotropica* 16: e20150151. <https://doi.org/10.1590/1676-0611-BN-2015-0151>
- Garavello JC (1979) Revisão taxonômica do gênero *Leporinus* Spix, 1829 (Ostariophysi, Anostomidae). PhD thesis, São Paulo, Brasil: Universidade de São Paulo, 175 pp.
- Garutti V, Britski HA (2000) Descrição de uma nova espécie de *Astyanax* (Teleostei: Characidae) da bacia do alto rio Paraná e considerações sobre as demais espécies do gênero na bacia. *Comunicações do Museu de Ciências e Tecnologia, PUCRS, série Zoologia* 13: 65–88.
- Gill TN (1858) Synopsis of the fresh water fishes of the western portion of the island of Trinidad, W. I. *Annals of the Lyceum of Natural History of New York* 6: 363–430.
- Giora J, Malabarba LR (2009) *Brachyhyopomus gauderio*, new species, a new example of underestimated species diversity of electric fishes in the southern South America (Gymnotiformes: Hypopomidae). *Zootaxa* 2093: 60–68.
- Giora J, Malabarba LR, Crampton W (2008) *Brachyhyopomus draco*, a new sexually dimorphic species of Neotropical electric fish from southern South America (Gymnotiformes: Hypopomidae). *Neotropical Ichthyology* 6: 159–168. <https://doi.org/10.1590/S1679-62252008000200002>
- Gomes AL (1956) Descrição de uma nova espécie de “*Luciopimelodinae*” do Rio Mogi Guaçu, Estado de São Paulo, (Pisces, Nemato-gnathi, Pimelodidae). *Revista Brasileira de Biologia* 16: 403–413.
- Graça WJ, Pavanelli CS (2007). Peixes da planície de inundação do alto rio Paraná e áreas adjacentes. EDUEM, Maringá, 241 pp.
- Hancock J (1828) Notes on some species of fishes and reptiles, from Demerara, presented to the Zoological Society by John Hancock, Esq., corr. memb. Zool. Soc. In a letter addressed to the secretary of the Society. *Zoological Journal* 4: 240–247.
- Hoffmann AC, Nascimento RHC, Shibatta OA (2015) Fish fauna from tributaries throughout the Tibagi river basin, upper Paraná, basin, Brazil. *Check List* 11: 1815. <https://doi.org/10.15560/11.6.1815>
- Hulsey CD, López-Fernández H (2011) Nuclear Central America. In: Albert JS, Reis RE (Eds) *Historical biogeography of Neotropical freshwater fishes*. University of California Press, Berkeley, 279–290.
- Ihering R (1911) Algumas especies novas de peixes d’agua doce (Nematognatha) (*Corydoras*, *Plecotomus*, *Hemipsilichthys*). *Revista do Museo São Paulo* 8: 380–404.
- Júlio-Júnior HF, Dei-Tós C, Agostinho AA, Pavanelli CS (2009) A massive invasion of fish species after eliminating a natural barrier in the upper rio Paraná basin. *Neotropical Ichthyology* 7: 709–718. <http://dx.doi.org/10.1590/S1679-62252009000400021>
- Kner R (1859) Zur Familie der Characinen. III. Folge der Ichthyologischen Beiträge. *Denkschriften der Kaiserlichen Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Classe* 17: 137–182.
- Kullander SO (1982) Cichlid fishes from the La Plata basin. Part III. The *Crenicichla lepidota* species group (Teleostei: Cichlidae). *Revue Suisse de Zoologie* 89: 627–661. <https://doi.org/10.5962/bhl.part.82465>
- Kullander SO (1983) A revision of the South American cichlid genus *Cichlasoma* (Teleostei: Cichlidae). *Swedish Museum of Natural History, Stockholm*, 296 pp.
- Langeani F, Casatti L, Gameiro HS, Bellucco-do-Carmo A, Rossa-Feres DC (2005) Riffle and pool fish communities in a large stream of southeastern Brazil. *Neotropical Ichthyology* 3: 305–311. <https://doi.org/10.1590/S1679-62252005000200009>
- Langeani F, Castro RMC, Oyakawa OT, Shibata OA, Pavanelli CS, Casatti L (2007) Diversidade da ictiofauna do alto rio Paraná: composição atual e perspectivas futuras. *Biota Neotropica* 7: 181–197. <https://doi.org/10.1590/S1676-06032007000300020>
- Lima RS (2003) Revisão taxonômica de *Aphyocharax* Günther, 1868 (Aphyocharacinae, Characidae, Ostariophysi). PhD thesis, São Paulo, Brasil: Universidade de São Paulo, 305 pp.
- Lowe-McConnell RH (1999) Estudos ecológicos de comunidades de peixes tropicais. EDUSP, São Paulo, 535 pp.
- Lucena CA, Soares HG (2016) Review of species of the *Astyanax bimaculatus* “caudal peduncle spot” subgroup sensu Garutti & Langeani (Characiformes, Characidae) from the rio La Plata and rio São Francisco drainages and coastal systems of southern Brazil and Uruguay. *Zootaxa* 4071: 101–125. <https://doi.org/10.11646/zootaxa.4071.1.5>
- Lucinda PHF, Reis RE (2005) Systematics of the subfamily Poeciliinae Bonaparte (Cyprinodontiformes, Poeciliidae). *Neotropical Ichthyology* 3: 1–60. <https://doi.org/10.1590/S1679-62252005000100001>
- Lucinda PHF (2008). Systematics and biogeography of the genus *Phalloceros* Eigenmann, 1907 (Cyprinodontiformes: Poeciliidae: Poeciliinae), with the description of twenty-one new species. *Neotropical Ichthyology* 6: 113–158. <https://doi.org/10.1590/S1679-62252008000200001>
- Lütken CF (1875) Characinae novae Brasiliae centralis a clarissimo J. Reinhardt in provincia Minas-Geraes circa oppidulum Lagoa Santa in lacu ejusdem nominis, flumine Rio das Velhas et rivulis affluentibus collectae, secundum caracteres essentielles breviter descriptae. *Oversigt over det Danske Videnskabernes Selskabs Forhandlinger* 1874: 127–143.
- Marzluff JM, Dial KP (1991) Life-history correlates of taxonomic

- diversity. *Ecology* 72: 428–439.
- Meinken H (1937) Beiträge zur Fischfauna des mittleren Paraná III. *Blätter für Aquarien-und Terrarienkunde* 48: 73–80.
- Mendonça A, Abelha MCF, Batista-Silva VF, Kashiwaqui EAL, Bailly D., Fernandes CA (2014) Population parameters of Poeciline in streams of Mato Grosso do Sul State, Brazil. *Boletim do Instituto de Pesca* 40: 557–567.
- Menezes (1987) Três novas espécies de *Oligosarcus* Günther, 1864 e redefinição taxonômica das demais espécies do gênero (Osteichthyes, Teleostei, Characidae). *Boletim de Zoologia da Universidade de São Paulo* 11: 1–39.
- Oliveira AG, Gomes LC, Latini, JD, Agostinho AA (2014). Implications of using a variety of fishing strategies and sampling techniques across different biotopes to determine fish species composition and diversity. *Natureza & Conservação* 12: 112–117. <https://doi.org/10.1016/j.ncon.2014.08.004>
- Oyakawa OT, Akama A, Zanata AM (2005) Review of the genus *Hypostomus* Lacépède, 1803 from rio Ribeira de Iguape basin, with description of a new species (Pisces, Siluriformes, Loricariidae). *Zootaxa* 921: 1–27. <https://doi.org/10.11646/zootaxa.921.1.1>
- Pavanelli CS (1999) Revisão taxonômica da família Parodontidae (Ostariophysi: Characiformes). PhD thesis, São Carlos, Brasil: Universidade Federal de São Carlos, 332 pp.
- Peixoto LAW, Dutra GM, Wosiacki WB (2015) The electric glass knifefishes of the Eigenmannia trilineata species-group (Gymnotiformes: Sternopygidae): monophyly and description of seven new species. *Zoological Journal of the Linnean Society* 175: 384–414. <https://doi.org/10.1111/zoj.12274>
- Pereira AL, Ribeiro VR, Gubiani ÉA, Zacarkim CE, Cunico AM (2014) Ichthyofauna of urban streams in the western region of Paraná State, Brazil. *Check List* 10: 550–555. <https://doi.org/10.15560/10.3.550>
- Pusey BJ, Arthington AH (2003) Conservation and management of freshwater fish: a review. *Marine and Freshwater Research* 54: 1–16. <https://doi.org/10.1071/MF02041>
- Purvis A, Orme CDL, Dolphin K (2003) Why are most species small bodied? A phylogenetic view. In: Gaston KJ, Blackburn TM (Eds) *Macroecology: concepts and consequences*. British Ecological Society Annual Symposia, Oxford, 155–173.
- Regan OT (1908) Descriptions of new loricariid fishes from South America. *Proceedings of the Zoological Society of London* 1907: 795–800. <https://doi.org/10.1111/j.1469-7998.1907.tb06957.x>
- Reinhardt JT (1867) Om trende, formeentligt ubeskrevne fisk af characinerne eller Karpelaxenes familie. Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandling og dets Medlemmers Arbejder (Kjøbenhavn) 1866: 49–68.
- Reis RE (1997) Revision of the neotropical catfish genus *Hoplosternum* (Ostariophysi, Siluriformes, Callichthyidae), with the description of two new genera and three new species. *Ichthyological Exploration of Freshwaters* 7: 299–326.
- Reis RE, Kullander SO, Ferraris CJ (2003) Check list of the freshwater fishes of South and Central America. EDIPUCRS, Porto Alegre, 742 pp.
- Reis RE, Albert JS, Di Dario F, Mincarone MM, Petry P, Rocha LA (2016) Fish biodiversity and conservation in South America. *Journal of Fish Biology* 89: 12–47. <https://doi.org/10.1111/jfb.13016>
- Rocha FC, Casatti L, Carvalho FR, Silva AM (2009) Fish assemblages in stream stretches occupied by cattail (Typhaceae, Angiospermae) stands in southeast Brazil. *Neotropical Ichthyology* 7: 241–250. <https://doi.org/10.1590/S1679-62252009000200016>
- Spix JB, Agassiz L. (1829-[31]). *Selecta genera et species piscium quos in itinere per Brasiliam annos MDCCCXVII–MDCCCXX jussu et auspiciis Maximiliani Josephi I.... Colleget et pingendso curavit Dr J. B. de Spix.... Part 1: i–xvi+ i–ii + 1–82, Pls. 1–48; part 2: 83–138, pls. 49–101*. Typis C. Wolf, Monachii. <https://doi.org/10.5962/bhl.title.9366>
- Steindachner F (1879) Über einige neue und seltene Fischarten aus den zoologischen Museen zu Wien, Stuttgart und Warschau. *Anzeiger der Kaiserlichen Akademie der Wissenschaften, Wien, Mathematisch-Naturwissenschaftliche Classe* 16: 29–34.
- Suárez YR, Petrere-Júnior M (2003) Associações de espécies de peixes em ambientes lóticos da bacia do rio Iguatemi, Estado do Mato Grosso do Sul. *Acta Scientiarum* 25: 361–367. <https://doi.org/10.4025/actascibiolsci.v25i2.2024>
- Suárez YR, Petrere-Júnior M (2005) Organização das assembleias de peixes em riachos da bacia do rio Iguatemi, estado do Mato Grosso do Sul. *Acta Scientiarum* 27: 161–167. <https://doi.org/10.4025/actascibiolsci.v27i2.1350>
- Suárez YR, Petrere-Júnior M (2006) Gradientes de diversidade nas comunidades de peixes da bacia do rio Iguatemi, Mato Grosso do Sul, Brasil. *Iheringia* 96: 197–204. <https://doi.org/10.1590/S0073-47212006000200009>
- Suárez YR, Lima-Júnior SE (2009) Variação espacial e temporal nas assembleias de peixes de riachos na bacia do rio Guirai, alto rio Paraná. *Biota Neotropica* 9: 101–111. <https://doi.org/10.1590/S1676-06032009000100012>
- Thomaz SM, Bini LM, Bozelli RL (2007) Floods increase similarity among aquatic habitats in river-floodplain systems. *Hydrobiologia* 579: 1–13. <https://doi.org/10.1007/s10750-006-0285-y>
- Thomaz AT, Arcila D, Orti G, Malabarba LR (2015) Molecular phylogeny of the subfamily Stevardiinae Gill, 1858 (Characiformes: Chracidae): classification and the evolution of reproductive traits. *BMC Evolutionary Biology* 15: 1–25. <https://doi.org/10.1186/s12862-015-0403-4>
- Travassos H (1956) Ictiofauna de Pirassununga. II. Sobre Characidiinae H. Travassos, 1952 (Cypriniformes–Characoidei). *Boletim do Museu Nacional do Rio de Janeiro, Zoologia, Nova Série* 135: 1–14.
- Valenciennes A (1835) Poissons [plate 2]. In: d’Orbigny A (Ed) *Voyage dans l’Amérique Méridionale (le Brésil, la République Orientale de l’Uruguay, la République Argentine, la Patagonie, la République du Chili, la République de Bolivie, la République du Pérou)*, exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1832 et 1833. Bertrand et Levrault, Paris.
- Valenciennes A (1839) *Voyage dans l’Amérique Méridionale (le Brésil, la République Orientale de l’Uruguay, la République Argentine, la Patagonie, la République du Chili, la République de Bolivie, la République du Pérou)*, exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1832 et 1833. Paris: Bertrand et Levrault. <https://doi.org/10.5962/bhl.title.85973>
- Vari RP (1991) Systematics of the neotropical characiform genus *Steidachnerina* Fowler (Pisces, Ostariophysi). *Smithsonian Contributions to Zoology* 507: 1–118.
- Vari RP (1992) Systematics of the Neotropical characiform genus *Cyphocharax* Fowler (Pisces, Ostariophysi). *Smithsonian Contributions to Zoology* 529: 1–137.
- Vari RP, Harold AS (2001) Phylogenetic study of the Neotropical fish genera *Creagrutus* Günther and *Piabina* Reinhardt (Teleostei: Ostariophysi: Characiformes), with a revision of the Cis-Andean species. *Smithsonian Contributions to Zoology* 613: 1–239.
- Viana D., Zawadzki CH, Oliveira EF, Vogel HF, Graça WJ (2013) Structure of the ichthyofauna of the Bonito river, Ivaí river basin, upper Paraná river system, Brazil. *Biota Neotropica* 13: 218–226. <https://doi.org/10.1590/S1676-06032013000200021>
- Winemiller KO, Agostinho AA, Caramaschi EP (2008) Fish ecology in tropical streams. In: Dudgeon D (Ed) *Tropical stream ecology*. Academic Press, San Diego, 107–146.